VELOCITY DETERMINATION FOR EJECTA FROM CRATERS IN COARSE-GRAINED SAND L. Berthoud, M.J. Cintala, and F. Hörz. Code SN4, NASA JSC, Houston, TX 77058.

Introduction - Impact plays a major role in the accretion and erosion processes which have shaped the solid bodies in the Solar System. When one body strikes another, the target is crushed by mechanical shock compression. The particles behind the compressive shock front are gradually turned upwards and ejected from the surface by rarefaction waves. Oberbeck and Morrison show that the ejecta assume the shape of a thin conical sheet or curtain containing material in ballistic trajectories [Oberbeck and Morrison, 1976]. A study of ejecta raises questions on the mechanism of fragmentation, the angles of ejection and the velocity of the ejecta.

Experimental setup - A fresh approach to this problem has been elaborated in the Experimental Impact Laboratory at NASA Johnson Space Center. A vertical powder propellant gun has been used to accelerate projectiles onto a blasting sand target (coarse-grained). The individual ejecta have been illuminated at known intervals by a strobed laser and imaged by a cooled charge-coupled-device (CCD) camera. This experimental setup is described in more detail by Cintala et al., 1997 [this volume]. The data in this work has been derived from an impact caused by a 3.18mm glass sphere impacting a target of blasting sand at a velocity of 1.127 km/s. A crater of 111 mm diameter (peak to peak) was created.

Data extraction - A series of flashes is created by the path of one ejecta particle being illuminated at periodic intervals. We can derive information about each ejecta particle which has a visible path. In order to derive the velocity of each particle, we use the known duration between flashes to give time information and direct digital images from the camera to give distance information. To extract the distance we have digitized the positions of the flashes on each trajectory. Some preliminary geometry calculations were then necessary to account for any possible rotation of the image. In order to extract time information, we coded the laser pulses. There were two bursts of five and ten pulses (each of 0.1 ms duration with gaps of 3.9ms between each pulse) and by inserting a long gap at the beginning and another gap after the first five pulses, we were able to get absolute times for the event.

Experiment Results - The x and y components of the velocities were used to calculate the following:

- x - the initial x position, i.e.: the origin of each ejecta particle along the x axis
- v_{y0} - the initial y velocity before the y component is affected by gravity
- the initial angle at which the particle is ejected
- the initial ejection velocity

These values were then compared to results from experiments by Oberbeck and Morrison who measured ejecta velocities for 1.5 km/s lexan projectile impacts into sand targets under Earth gravity [Oberbeck and Morrison, 1976]. Fig. 1 shows the initial ejection velocity in terms of the launch position: '$x_{/R}$' where R is the radius of the crater. The data show that the velocity decreases with distance from the impact origin, although it would be desirable to have more points between 0.05 < x/R < 1 to confirm this. The data so far indicate an exponential decrease of velocity with distance from impact origin. Oberbeck and Morrison's data however, indicated a linear decrease of velocity with distance. The scatter in our data may partly due to the saturation of the pixels in the CCD image which causes the dots to become larger. This problem will be improved in the next stage of experimentation. Fig. 2 shows the initial ejection angle in terms of the distance x/R for both our results and those of Oberbeck and Morrison. Both results show an approximately constant ejection angle for increasing launch distance. Note that the trajectories chosen for digitizising did not include the almost vertical jets of material moving at hypervelocity. These jets would result in a different ejection angle to that described here.

Our results confirm findings that the more vertical trajectories contain material ejected at early stages in the cratering at higher velocities and the small almost horizontal trajectories contain material ejected at lower velocities at a later stage [Andrews, 1977]. With the impact conditions described, much of the material has been ejected by the end of the pulse signal (after 120 ms), although the more horizontal parabolas of the slowest ejecta cannot be seen.

Future Work - One of the main aims of these experiments is to establish a general relation between ejection velocities and initial impact conditions (projectile and target materials and sizes, impact velocity) by using projectiles of polyethylene, aluminum, stainless steel and tungsten carbide, and by using targets of sand, Kaolinite and eventually rock at different impact velocities. At a later stage it is planned to use an airgun to extend the range of velocities downwards into the hundreds of m/s.

References -

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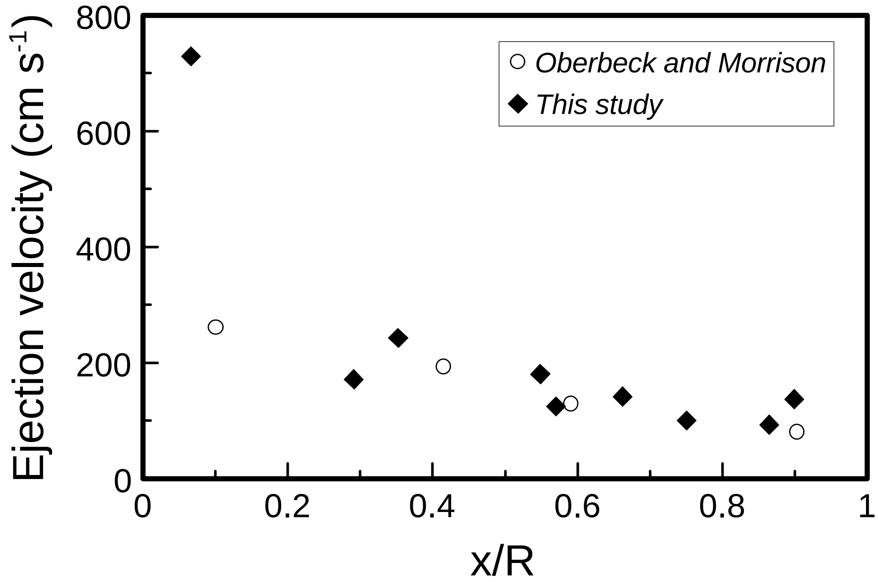

Figure 1. Ejection velocity as a function of distance from the impact point, normalized to the crater radius. Note the increase in ejection velocity as the impact point is approached.

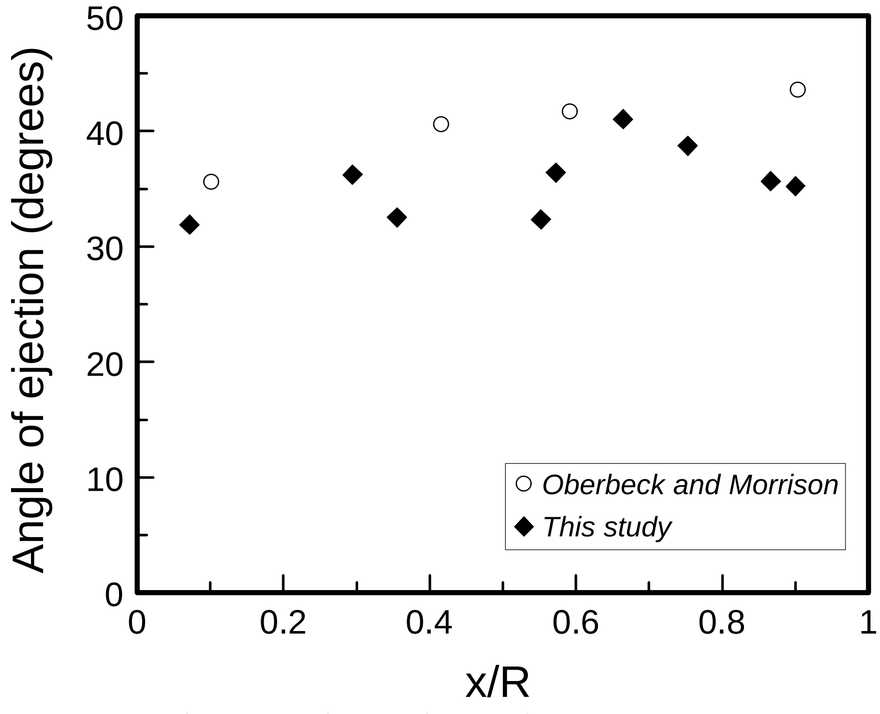

Figure 2. Angle of ejection as a function of distance from the impact point, normalized to the crater radius.